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# RESEARCH MEMORANDUM

## INVESTIGATION OF A TRAILING-EDGE PADDLE-CONTROL SURFACE ON A TRIANGULAR WING OF ASPECT RATIO 2 AT SUBSONIC AND SUPERSONIC SPEEDS

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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# INVESTIGATION OF A TRAILING-EDGE PADDLE-CONTROL SURFACE ON A TRIANGULAR WING OF ASPECT RATIO 2 AT SUBSONIC AND SUPERSONIC SPEEDS

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## SUMMARY

Presented herein are the results of an experimental investigation of external airfoils, known as paddle-control surfaces, as the longitudinal control device on a triangular wing of aspect ratio 2. The lift, drag, pitching moment, and hinge moment were obtained for Mach numbers of 0.60, 0.80, 0.90, 1.20, 1.30, 1.50, 1.70, and 1.90 at a constant Reynolds number of $3.0 \times 10^6$, for angles of attack from about $-4^\circ$ to $18^\circ$ and for paddle-control deflections from approximately $4^\circ$ to $-16^\circ$.

Examination of the control-surface characteristics of the paddle control and comparison of the control-surface parameters with a conventional trailing-edge unbalanced flap having the same area revealed the following results:

No unusual variations were noted in the pitching-moment or hinge-moment characteristics throughout the speed range tested. The pitching-moment effectiveness of the paddle control at subsonic speeds was considerably less than that of the unbalanced flap. At supersonic speeds, the pitching-moment effectiveness of the paddle control was less than that of the unbalanced flap at Mach numbers below 1.50; whereas, above a Mach number of 1.50, the effectiveness of the two types of controls corresponded closely. The results showed that material reductions in the hinge-moment parameters, $C_{h_\delta}$ and $C_{h_\alpha}$, were realized with the paddle control. There was little effect of Mach number on these hinge-moment parameters.

The use of the paddle control resulted in increases in the minimum drag coefficient throughout the speed range investigated.

## INTRODUCTION

As part of a continuing experimental program to find methods to reduce the control moments of trailing-edge controls on high-speed aircraft, an external airfoil control surface was tested in the Ames 6- by 6-foot supersonic wind tunnel. Previous tests (ref. 1) have shown that the use of an external airfoil, called a paddle, as a balancing device in combination with a trailing-edge flap provided substantial reductions in the hinge moments due to control deflections at supersonic speeds. A study of these data indicated that such a paddle could be used as the primary longitudinal-control device and, by virtue of the interaction between the control and the wing, could be designed to have small hinge moments at both subsonic and supersonic speeds.

The present investigation was undertaken, therefore, to provide information on the control characteristics of the paddle control.

## SYMBOLS

$b$ wing span, ft

$c$ local wing chord measured parallel to plane of symmetry, ft

$\bar{c}$ wing mean aerodynamic chord, $\dfrac{\int_0^{b/2} c^2 dy}{\int_0^{b/2} c\, dy}$, ft

$C_D$ drag coefficient, $\dfrac{\text{drag}}{qS}$

$C_{D_o}$ minimum drag coefficient

$C_h$ hinge-moment coefficient, $\dfrac{\text{hinge moment}}{2qM_A}$

$C_L$ lift coefficient, $\dfrac{\text{lift}}{qS}$

$C_m$ pitching-moment coefficient about the 35-percent point of the wing mean aerodynamic chord, $\dfrac{\text{pitching moment}}{qS\bar{c}}$

$C_{m_\delta}$ control pitching-moment-effectiveness parameter for constant angle of attack, $\dfrac{\partial C_m}{\partial \delta}$, measured at $\delta = 0^\circ$, per deg

$C_{L_\delta}$ control lift-effectiveness parameter for constant angle of attack, $\dfrac{\partial C_L}{\partial \delta}$, measured at $\delta = 0^\circ$, per deg

$C_{h_\delta}$ rate of change of hinge-moment coefficient with change in control deflection for constant angle of attack, $\frac{\partial C_h}{\partial \delta}$, measured at $\delta = 0^\circ$, per deg

$C_{h_\alpha}$ rate of change of hinge-moment coefficient with change in angle of attack for constant angle of control deflection, $\frac{\partial C_h}{\partial \alpha}$, measured at $\alpha = 0^\circ$, per deg

$l$ length of body including portion removed to accommodate sting, ft

M Mach number

$M_A$ first moment of area of exposed flap area aft of hinge line of the unbalanced flap,[1] $ft^3$ (see ref. 1)

q free-stream dynamic pressure, $\frac{\rho V^2}{2}$, lb/sq ft

R Reynolds number, based on mean aerodynamic chord

$r_o$ maximum body radius, ft

S wing area, including area within body, sq ft

V velocity of free stream, ft/sec

x longitudinal distance from nose of body, ft

y distance perpendicular to vertical plane of symmetry, ft

$\alpha$ angle of attack of wing chord line, deg

$\delta$ angle between wing chord and control chord measured in a plane perpendicular to the control hinge line, positive for downward deflection with respect to the wing, deg

$\rho$ mass density of air, slugs/cu ft

Subscript

n nominal control angle

[1]In order that the hinge-moment coefficients of the paddle control and the unbalanced flap could be compared, the hinge-moment coefficients of the paddle control were computed using the moment of area of the unbalanced flap of reference 1.

## APPARATUS AND MODEL

The Ames 6- by 6-foot supersonic wind tunnel in which this investigation was conducted is a closed-return, variable-pressure wind tunnel with a Mach number range from 0.60 to 0.90 and from 1.20 to 2.00. Further information on this wind tunnel can be found in reference 2.

The model consisted of a wing-fuselage combination employing a wing of triangular plan form of aspect ratio 2 symmetrically mounted on the fuselage. The wing had NACA 0005-63 airfoil sections in streamwise planes.

The paddle control consisted of two sharp-edge rectangular surfaces (fig. 1). One of the paddles was positioned above and the other was positioned below the trailing edge of the right wing by a pair of struts which attached the paddles rigidly together and positioned each paddle 1.30 inches from the chord plane of the wing. The struts were pivoted about an axis in the chord plane of the wing which corresponded to the 30-percent-chord line of the paddles as a means of obtaining various deflection angles. When the control was undeflected, the trailing edges of the two paddles were in the same plane as the wing trailing edge. The streamwise airfoil section of the paddles was a half circular arc with the convexity on the side opposite to the wing. The maximum thickness-chord ratio was approximately 5 percent at the 50-percent chord. The area of the two paddles combined equalled approximately 14 percent of the area of the right wing panel including that portion enclosed within the body.

The wing and paddle control were of solid steel construction. The body had a fineness ratio of 12.5 based on the length including that portion shown dotted in figure 1.

The forces and moments on the model were measured by an electrical strain-gage balance. Paddle-control hinge moments were measured by an electrical strain gage mounted within the wing.

## TEST AND PROCEDURE

The aerodynamic characteristics of the model as a function of angle of attack were investigated for a range of Mach numbers from 0.60 to 0.90 and from 1.20 to 1.90. The data presented were obtained at a Reynolds number of $3.0 \times 10^6$. Lift, drag, pitching-moment, and hinge-moment measurements were made at constant paddle-control deflections for angles of attack from about $-4^\circ$ to $18^\circ$. The paddle-control deflections were varied from $4^\circ$ to $-16^\circ$. In some instances, the full range of angles of attack was not obtained because of structural limitations or other difficulties.

## Reduction of Data

The test data have been reduced to standard NACA coefficient form. The pitching moments were calculated about an axis at 35 percent of the mean aerodynamic chord. A complete discussion of the methods used in reducing the wind-tunnel data to coefficient form and the various corrections applied to the results may be found in reference 1 and only brief mention will be made here.

The data obtained in the Ames 6- by 6-foot supersonic wind tunnel have been corrected for the following factors:

1. Induced effects of the tunnel walls at subsonic speeds resulting from lift on the model.

2. The change in the airspeed in the vicinity of the model at subsonic speeds resulting from the constriction of the flow by the tunnel walls.

3. The pressure at the base of the model at supersonic and subsonic speeds being affected by the support interference. To account partially for this effect, the base pressure was measured and the drag coefficient was adjusted to correspond to that in which the base pressure would be equal to the free-stream static pressure.

4. The longitudinal force on the model at subsonic and supersonic speeds due to the streamwise variation of the static pressure as measured in the empty test section.

A survey of the 6- by 6-foot wind tunnel also indicated nonuniformities of the air stream in the pitch plane of the model equivalent to a stream angle of as much as 0.10°. No correction to the data was made for this effect.

## Precision

The uncertainties involved in determining dynamic pressure and in measuring forces with the strain-gage balance are described in reference 3. The following table lists the uncertainty introduced into each corrected coefficient by the known uncertainties in the measurements:

| Quantity | Uncertainty |
|---|---|
| Lift coefficient | ±0.002 |
| Drag coefficient | ±.001 |
| Pitching-moment coefficient | ±.002 |
| Hinge-moment coefficient | ±.004 |
| Mach number | ±.01 |
| Reynolds number | $\pm .03 \times 10^6$ |
| Angle of attack | $\pm .10^\circ$ |
| Flap deflection angle | $\pm .25^\circ$ |

## RESULTS AND DISCUSSION

The results of the investigation of the paddle control are presented in tabular form for the complete range of test variables in table I. The data presented in the table are for the model equipped with a paddle control on the right wing panel. For the purpose of analysis, a representative portion of the data is presented in graphical form.

Figure 2 shows the variation of the pitching-moment and the hinge-moment coefficients with paddle-control deflection for given angles of attack and with angle of attack for given paddle-control deflections. Only the data for the representative Mach numbers of 0.60, 0.90, 1.30, and 1.90 are presented. The results shown in figure 2 are for deflections of the paddle control on the right wing panel. The data reveal no unusual variations of the pitching-moment and the hinge-moment coefficients with either angle of attack or angle of deflection throughout the speed range of these tests.

The pitching-moment-effectiveness parameter, $C_{m_\delta}$, the hinge-moment parameters, $C_{h_\delta}$ and $C_{h_\alpha}$, and the minimum-drag coefficient of the paddle control are presented as functions of Mach number in figure 3. For purposes of comparison, the corresponding data for the unbalanced flap configuration of reference 1 are also presented in figure 3. Although data were obtained for the paddle control on only the right wing panel, the results, as presented in figure 3, are for the deflection of a control on both wing panels.

The pitching-moment effectiveness of the paddle control was less than the unbalanced flap at all speeds tested below a Mach number of 1.50; whereas, above the Mach number 1.50, the effectiveness of the two types of controls corresponded closely. The marked loss in pitching-moment effectiveness, $C_{m_\delta}$, of the paddle control from that shown for the unbalanced flap at subsonic speeds may be advantageous in reducing the sensitivity of the longitudinal control in this speed range. The reduced effectiveness of the paddle control at subsonic speeds is believed due to the absence of the additional lift induced on the forward portion of the wing by the hinged flap. The decrease in effectiveness exhibited by the paddle control at supersonic speeds below a Mach number of 1.50 is brought about as a result of the shock-expansion interference between the paddles and the wing. This principle has been discussed previously in reference 1 and will be only briefly related here. At negative control deflections the lower surface of the upper paddle propagates expansion waves which impinge on the wing surface. The resulting increase in lift on the wing, being of the opposite sign to that carried by the paddle due to control deflection, effects a net reduction in the lift effectiveness, $C_{L_\delta}$, of the paddle control and, thereby, the pitching-moment effectiveness of the control. The paddle mounted on the lower surface of the wing acts in an analogous manner by virtue of the compression wave emitted from its upper surface. At Mach numbers above 1.50, the paddle control was so located that the shock waves emanating from the paddles do not strike the wing surface. Therefore, at these Mach numbers, the pitching-moment effectiveness of the two types of controls corresponded closely.

The preceding discussion must be acknowledged to be a simplification of the flow phenomena involved. However, it is believed to describe the primary cause for the differences in pitching-moment effectiveness between the paddle control and the unbalanced flap.

The primary advantage of the paddle control over the flap-type control is evident in the hinge-moment characteristics. An examination of figure 3 shows that material reductions are realized for both of the hinge-moment parameters, $C_{h_\delta}$ and $C_{h_\alpha}$, from that noted for the unbalanced flap throughout the speed range investigated. Figure 3 also shows that there is little effect of Mach number on the hinge-moment parameters of the paddle control. The small values of $C_{h_\alpha}$ noted for this control can be attributed primarily to the influence of the wing surface which causes the effective incidence of the paddles to be essentially the same throughout the angle-of-attack range of the tests. This influence of the wing on the paddles is consistent with the results of reference 1 which showed that the addition of a paddle balance to a conventional trailing-edge unbalanced flap had little effect on $C_{h_\alpha}$ of the unbalanced control. Since this phenomenon is essentially independent of speed, $C_{h_\alpha}$ is unaffected by Mach number (see fig. 3). The reduction noted in $C_{h_\delta}$ was due in part to the aerodynamic balance incorporated in the paddle control. The small effect of Mach number on $C_{h_\delta}$ is not clearly understood. It would be expected that there would be an effect of Mach number on the hinge moment due to flap deflection because of the rearward shift in the center of pressure of the load on the control surface with increasing Mach number. It is somewhat surprising that this effect is not evident in the hinge-moment results.

The hinge-moment advantages of the paddle control were obtained with a penalty in the drag characteristics, as shown in figure 3. The results show that the paddle control exhibited higher minimum drag coefficients than the unbalanced flap throughout the speed range tested. It is of interest to note that, though the drag increment is fairly large, considerable improvement in the drag characteristics was realized for the paddle control of the present investigation over the paddle balance of reference 1 by reducing the paddle thickness.

## CONCLUSIONS

Tests were made of a model equipped with a trailing-edge paddle-control device to determine its control characteristics at subsonic and supersonic speeds. The results were compared with the control characteristics of the unbalanced, trailing-edge flap of reference 1. Examination of the results revealed the following significant features:

1. The pitching-moment and hinge-moment characteristics of the paddle control showed no outstanding nonlinearities for the entire speed range studied.

2. The paddle control exhibited a smaller control effectiveness at subsonic speeds and at supersonic speeds below a Mach number of 1.50. Above the Mach number 1.50 the effectiveness of the two types of controls corresponded closely.

3. The hinge-moment parameters, $C_{h_\delta}$ and $C_{h_\alpha}$, of the paddle control were considerably smaller than those of the unbalanced flap and were little affected by Mach number.

4. The paddle control increased the minimum drag throughout the speed range tested.

Ames Aeronautical Laboratory
National Advisory Committee for Aeronautics
Moffett Field, Calif., Nov. 20, 1953

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3. Hall, Charles F., and Heitmeyer, John C.: Aerodynamic Study of a Wing-Fuselage Combination Employing a Wing Swept Back 63°.- Characteristics at Supersonic Speeds of a Model With the Wing Twisted and Cambered for Uniform Load. NACA RM A9J24, 1950.

TABLE I.- AERODYNAMIC CHARACTERISTICS OF A TRIANGULAR WING EQUIPPED WITH A PADDLE CONTROL. DATA FOR ONE PADDLE CONTROL. $R = 3.0\times10^6$

(a) Nominal $\delta = +4^\circ$

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 0.60 | -4.16 | -0.176 | 0.0176 | 0.001 | -0.030 | 3.9 |
| | -2.05 | -.082 | .0119 | -.005 | -.035 | 3.8 |
| | -1.06 | -.037 | .0104 | -.008 | -.038 | 3.8 |
| | -.53 | -.014 | .0100 | -.009 | -.039 | 3.8 |
| | .47 | .031 | .0100 | -.011 | -.040 | 3.8 |
| | 1.00 | .055 | .0106 | -.012 | -.041 | 3.8 |
| | 2.06 | .104 | .0129 | -.015 | -.041 | 3.8 |
| | 4.16 | .199 | .0202 | -.021 | -.043 | 3.8 |
| | 6.26 | .296 | .0332 | -.027 | -.045 | 3.8 |
| | 8.36 | .395 | .0567 | -.028 | -.047 | 3.8 |
| | 10.47 | .486 | .0860 | -.023 | -.043 | 3.8 |
| | 12.58 | .589 | .1260 | -.022 | -.038 | 3.8 |
| | 14.69 | .693 | .1737 | -.023 | -.036 | 3.8 |
| | 16.81 | .798 | .2303 | -.023 | -.036 | 3.8 |
| | 17.87 | .853 | .2626 | -.022 | -.037 | 3.8 |
| 0.80 | -4.19 | -.185 | .0194 | .004 | -.024 | 3.9 |
| | -2.07 | -.084 | .0126 | -.004 | -.024 | 3.9 |
| | -1.07 | -.037 | .0110 | -.008 | -.026 | 3.9 |
| | -.53 | -.015 | .0104 | -.009 | -.031 | 3.8 |
| | .48 | .035 | .0107 | -.013 | -.031 | 3.8 |
| | 1.01 | .059 | .0113 | -.014 | -.033 | 3.8 |
| | 2.08 | .109 | .0135 | -.017 | -.039 | 3.8 |
| | 4.19 | .211 | .0219 | -.025 | -.042 | 3.8 |
| | 6.31 | .317 | .0379 | -.032 | -.045 | 3.7 |
| | 8.43 | .413 | .0618 | -.030 | -.044 | 3.8 |
| | 10.54 | .505 | .0947 | -.027 | -.037 | 3.8 |
| | 12.67 | .616 | .1384 | -.037 | -.031 | 3.8 |
| | 14.80 | .726 | .1910 | -.042 | -.029 | 3.8 |
| | 16.93 | .840 | .2543 | -.048 | -.030 | 3.8 |
| 0.90 | -4.21 | -.198 | .0226 | .008 | -.026 | 3.8 |
| | -2.09 | -.090 | .0141 | -.002 | -.024 | 3.9 |
| | -1.07 | -.040 | .0122 | -.007 | -.026 | 3.8 |
| | -.53 | -.013 | .0116 | -.009 | -.025 | 3.8 |
| | .48 | .037 | .0117 | -.013 | -.025 | 3.8 |
| | 1.02 | .064 | .0125 | -.015 | -.027 | 3.8 |
| | 2.09 | .117 | .0185 | -.019 | -.027 | 3.8 |
| 0.90 | 4.21 | 0.228 | 0.0255 | -0.029 | -0.028 | 3.8 |
| | 6.34 | .342 | .0442 | -.038 | -.035 | 3.8 |
| | 8.46 | .433 | .0697 | -.036 | -.039 | 3.8 |
| | 10.59 | .532 | .1057 | -.040 | -.030 | 3.8 |
| 1.20 | -4.09 | -.201 | .0277 | .030 | -.029 | 3.8 |
| | -2.03 | -.097 | .0184 | .011 | -.029 | 3.8 |
| | -1.00 | -.047 | .0162 | .003 | -.029 | 3.8 |
| | -.47 | -.023 | .0157 | -.001 | -.030 | 3.8 |
| | .46 | .025 | .0156 | -.009 | -.031 | 3.8 |
| | .98 | .052 | .0164 | -.014 | -.031 | 3.8 |
| | 2.02 | .106 | .0193 | -.023 | -.031 | 3.8 |
| | 4.08 | .209 | .0290 | -.041 | -.035 | 3.7 |
| | 6.14 | .316 | .0459 | -.059 | -.038 | 3.7 |
| | 8.20 | .421 | .0708 | -.076 | -.030 | 3.8 |
| | 10.27 | .527 | .1037 | -.092 | -.024 | 3.8 |
| 1.30 | -4.09 | -.185 | .0293 | .025 | -.029 | 3.8 |
| | -2.03 | -.089 | .0206 | .008 | -.029 | 3.8 |
| | -1.00 | -.044 | .0183 | .001 | -.029 | 3.8 |
| | -.53 | -.022 | .0178 | -.003 | -.028 | 3.8 |
| | .45 | .024 | .0177 | -.009 | -.028 | 3.8 |
| | .98 | .048 | .0185 | -.013 | -.028 | 3.8 |
| | 2.02 | .097 | .0215 | -.022 | -.028 | 3.8 |
| | 4.08 | .193 | .0306 | -.037 | -.028 | 3.8 |
| | 6.13 | .290 | .0461 | -.052 | -.029 | 3.8 |
| | 8.19 | .382 | .0685 | -.067 | -.028 | 3.8 |
| | 10.25 | .476 | .0983 | -.081 | -.026 | 3.8 |
| | 12.31 | .567 | .1345 | -.094 | -.023 | 3.8 |
| 1.50 | -4.08 | -.170 | .0271 | .023 | -.020 | 3.8 |
| | -2.03 | -.083 | .0188 | .008 | -.026 | 3.8 |
| | -.99 | -.041 | .0164 | .001 | -.027 | 3.8 |
| | -.53 | -.020 | .0155 | -.002 | -.027 | 3.8 |
| | .45 | .021 | .0153 | -.008 | -.028 | 3.8 |
| | .98 | .044 | .0163 | -.012 | -.029 | 3.8 |
| 1.50 | 2.02 | 0.089 | 0.0194 | -0.019 | -0.030 | 3.8 |
| | 4.07 | .177 | .0261 | -.034 | -.031 | 3.8 |
| | 6.12 | .263 | .0424 | -.047 | -.031 | 3.8 |
| | 8.18 | .345 | .0621 | -.060 | -.030 | 3.8 |
| | 10.23 | .427 | .0884 | -.072 | -.028 | 3.8 |
| | 12.29 | .506 | .1199 | -.083 | -.024 | 3.8 |
| | 14.35 | .582 | .1571 | -.093 | -.023 | 3.8 |
| 1.70 | -4.07 | -.156 | .0257 | .020 | -.023 | 3.8 |
| | -2.03 | -.078 | .0178 | .008 | -.023 | 3.8 |
| | -.99 | -.039 | .0158 | .002 | -.023 | 3.8 |
| | -.47 | -.020 | .0152 | -.001 | -.024 | 3.8 |
| | .45 | .018 | .0152 | -.006 | -.024 | 3.8 |
| | .98 | .039 | .0157 | -.010 | -.024 | 3.8 |
| | 2.01 | .079 | .0179 | -.016 | -.025 | 3.8 |
| | 4.06 | .159 | .0259 | -.029 | -.026 | 3.8 |
| | 6.11 | .237 | .0390 | -.040 | -.027 | 3.8 |
| | 8.16 | .313 | .0572 | -.051 | -.028 | 3.8 |
| | 10.21 | .383 | .0804 | -.062 | -.027 | 3.8 |
| | 12.26 | .453 | .1086 | -.071 | -.027 | 3.8 |
| | 14.31 | .522 | .1423 | -.080 | -.028 | 3.8 |
| | 16.37 | .589 | .1806 | -.086 | -.030 | 3.8 |
| 1.90 | -4.06 | -.142 | .0247 | .017 | -.018 | 3.9 |
| | -2.02 | -.071 | .0177 | .007 | -.018 | 3.9 |
| | -.98 | -.036 | .0160 | .002 | -.018 | 3.9 |
| | -.47 | -.019 | .0156 | -.001 | -.019 | 3.9 |
| | .45 | .015 | .0155 | -.006 | -.019 | 3.9 |
| | .97 | .034 | .0160 | -.008 | -.019 | 3.9 |
| | 2.01 | .071 | .0178 | -.014 | -.019 | 3.9 |
| | 4.05 | .141 | .0248 | -.024 | -.020 | 3.8 |
| | 6.09 | .209 | .0364 | -.034 | -.021 | 3.8 |
| | 8.14 | .278 | .0528 | -.043 | -.022 | 3.8 |
| | 10.18 | .342 | .0735 | -.052 | -.023 | 3.8 |
| | 12.23 | .405 | .0987 | -.060 | -.024 | 3.8 |
| | 14.27 | .466 | .1286 | -.066 | -.025 | 3.8 |
| | 16.32 | .527 | .1631 | -.071 | -.028 | 3.8 |
| | 17.35 | .559 | .1826 | -.072 | -.032 | 3.8 |

(b) Nominal $\delta = 0^\circ$

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 0.60 | -4.16 | -0.195 | 0.0184 | 0.011 | -0.004 | 0 |
| | -2.07 | -.103 | .0117 | .006 | -.006 | 0 |
| | -.48 | -.035 | .0090 | .002 | -.008 | 0 |
| | .45 | .007 | .0088 | -.001 | -.009 | 0 |
| | .98 | .031 | .0092 | -.002 | -.010 | 0 |
| | 2.04 | .077 | .0107 | -.005 | -.011 | 0 |
| | 4.14 | .172 | .0170 | -.010 | -.013 | -.1 |
| | 6.24 | .270 | .0301 | -.017 | -.016 | -.1 |
| | 8.34 | .368 | .0511 | -.019 | -.012 | -.1 |
| | 10.44 | .459 | .0795 | -.015 | -.009 | 0 |
| | 12.55 | .567 | .1194 | -.016 | -.007 | 0 |
| | 14.66 | .663 | .1642 | -.018 | -.006 | 0 |
| | 16.77 | .770 | .2198 | -.018 | -.006 | 0 |
| | 17.83 | .819 | .2494 | -.018 | -.008 | 0 |
| 0.80 | -4.19 | -.205 | .0201 | .015 | .001 | 0 |
| | -2.09 | -.109 | .0121 | .007 | -.003 | 0 |
| | -1.02 | -.059 | .0097 | .004 | -.004 | 0 |
| | -.49 | -.034 | .0091 | .002 | -.004 | 0 |
| | .45 | .010 | .0089 | -.001 | -.005 | 0 |
| | .99 | .034 | .0094 | -.003 | -.005 | 0 |
| | 2.06 | .083 | - - - | -.006 | -.006 | 0 |
| | 4.17 | .185 | .0190 | -.014 | -.009 | 0 |
| | 6.28 | .290 | .0336 | -.022 | -.015 | -.1 |
| | 8.40 | .388 | .0578 | -.021 | -.014 | -.1 |
| | 10.51 | .475 | .0882 | -.019 | -.015 | -.1 |
| | 12.63 | .591 | .1321 | -.030 | -.022 | -.1 |
| | 14.76 | .695 | .1816 | -.034 | -.022 | -.1 |
| | 16.89 | .808 | .2426 | .042 | -.023 | -.1 |
| | 17.95 | .862 | .2760 | .047 | -.026 | -.1 |
| 0.90 | -4.22 | -.221 | .0232 | .018 | .007 | 0 |
| | -2.10 | -.111 | .0135 | .008 | .005 | 0 |
| | -1.03 | -.060 | .0110 | .004 | 0 | 0 |
| | -.49 | -.035 | .0103 | .002 | 0 | 0 |
| | .46 | .011 | .0099 | -.001 | -.001 | 0 |
| | .99 | .037 | .0105 | -.003 | 0 | 0 |
| | 2.07 | .090 | .0128 | -.005 | -.004 | 0 |
| 0.90 | 4.19 | 0.199 | 0.0217 | -0.017 | -0.003 | 0 |
| | 6.31 | .306 | .0382 | -.024 | -.009 | -.1 |
| | 8.43 | .402 | .0632 | -.024 | -.005 | 0 |
| | 10.56 | .510 | .0984 | -.031 | -.002 | 0 |
| 1.20 | -4.09 | -.215 | .0283 | .038 | .009 | .1 |
| | -2.03 | -.110 | .0189 | .019 | .006 | 0 |
| | -1.00 | -.059 | .0158 | .010 | .006 | 0 |
| | -.47 | -.033 | .0151 | .006 | .003 | 0 |
| | .45 | .013 | .0150 | -.002 | .001 | 0 |
| | .98 | .040 | .0157 | -.007 | -.001 | 0 |
| | 2.02 | .092 | .0181 | -.015 | -.001 | 0 |
| | 4.08 | .196 | .0272 | -.033 | -.003 | 0 |
| | 6.14 | .305 | .0437 | -.051 | -.004 | 0 |
| | 8.20 | .407 | .0679 | -.068 | .003 | 0 |
| | 10.27 | .513 | .1001 | -.084 | .005 | 0 |
| 1.30 | -4.09 | -.198 | .0298 | .032 | .001 | 0 |
| | -2.03 | -.102 | .0206 | .016 | .004 | 0 |
| | -1.00 | -.055 | .0180 | .009 | .003 | 0 |
| | -.47 | -.031 | .0174 | .005 | .003 | 0 |
| | .45 | .012 | .0171 | -.002 | .003 | 0 |
| | .98 | .036 | .0178 | -.006 | .003 | 0 |
| | 2.02 | .085 | .0219 | -.014 | .001 | 0 |
| | 4.07 | .181 | .0288 | -.030 | .003 | 0 |
| | 6.13 | .278 | .0438 | -.044 | .006 | 0 |
| | 8.19 | .371 | .0657 | -.059 | .005 | 0 |
| | 10.25 | .464 | .0948 | -.073 | .004 | 0 |
| | 12.31 | .555 | .1304 | -.087 | .005 | 0 |
| | 14.37 | .644 | .1727 | -.099 | .003 | 0 |
| 1.50 | -4.08 | -.181 | .0272 | .029 | .006 | 0 |
| | -2.02 | -.093 | .0185 | .015 | .004 | 0 |
| | -.99 | -.049 | .0159 | .008 | .003 | 0 |
| | -.47 | -.027 | .0148 | .005 | .003 | 0 |
| | .45 | .012 | .0146 | -.002 | .001 | 0 |
| | .97 | .034 | .0156 | -.006 | .001 | 0 |
| | 2.02 | .078 | .0182 | -.013 | 0 | 0 |
| 1.50 | 4.07 | 0.166 | 0.0264 | -0.027 | -0.002 | 0 |
| | 6.12 | .254 | .0402 | -.040 | -.003 | 0 |
| | 8.17 | .336 | .0600 | -.053 | -.003 | 0 |
| | 10.23 | .419 | .0940 | -.066 | -.004 | 0 |
| | 12.28 | .498 | .1170 | -.077 | -.003 | 0 |
| | 14.34 | .575 | .1550 | -.087 | .001 | 0 |
| 1.70 | -4.07 | -.164 | .0254 | .026 | .004 | 0 |
| | -2.02 | -.085 | .0173 | .013 | .003 | 0 |
| | -.99 | -.046 | .0152 | .007 | .002 | 0 |
| | -.47 | -.026 | .0145 | .004 | .001 | 0 |
| | .45 | .011 | .0144 | -.002 | .001 | 0 |
| | .97 | .031 | .0149 | -.005 | .006 | 0 |
| | 2.01 | .071 | .0169 | -.011 | 0 | 0 |
| | 4.07 | .150 | .0245 | -.023 | -.001 | 0 |
| | 6.12 | .228 | .0370 | -.035 | -.002 | 0 |
| | 8.17 | .306 | .0550 | -.046 | -.004 | 0 |
| | 10.22 | .376 | .0777 | -.057 | -.005 | 0 |
| | 12.27 | .447 | .1058 | -.066 | -.006 | 0 |
| | 14.32 | .516 | .1393 | -.075 | -.007 | -.1 |
| | 16.38 | .562 | .1773 | -.081 | -.011 | -.1 |
| 1.90 | -4.06 | -.149 | .0248 | .022 | .003 | 0 |
| | -2.02 | -.077 | .0174 | .011 | .002 | 0 |
| | -.99 | -.042 | .0157 | .006 | .002 | 0 |
| | -.47 | -.025 | .0151 | .004 | .002 | 0 |
| | .45 | .008 | .0150 | -.001 | .001 | 0 |
| | .97 | .026 | .0154 | -.004 | .001 | 0 |
| | 2.01 | .064 | .0170 | -.010 | 0 | 0 |
| | 4.05 | .135 | .0237 | -.020 | -.001 | 0 |
| | 6.10 | .204 | .0350 | -.030 | -.002 | 0 |
| | 8.14 | .273 | .0511 | -.039 | -.003 | 0 |
| | 10.19 | .338 | .0714 | -.048 | -.005 | 0 |
| | 12.23 | .401 | .0962 | -.056 | -.007 | 0 |
| | 14.28 | .462 | .1258 | -.062 | -.008 | -.1 |
| | 16.33 | .524 | .1606 | -.067 | -.012 | -.1 |
| | 17.36 | .556 | .1801 | -.069 | -.016 | -.1 |

NACA

TABLE I.- AERODYNAMIC CHARACTERISTICS OF A TRIANGULAR WING EQUIPPED WITH A PADDLE CONTROL. DATA FOR ONE PADDLE CONTROL. $R = 3.0\times10^6$ - Continued

(c) Nominal $\delta = -4^\circ$

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 0.60 | -4.18 | -0.219 | 0.0212 | 0.022 | 0.030 | -4.1 |
| | -2.09 | -.127 | .0137 | .016 | .029 | -4.1 |
| | -1.03 | -.080 | .0113 | .014 | .028 | -4.1 |
| | -.50 | -.058 | .0105 | .013 | .028 | -4.1 |
| | .49 | -.014 | - - - | .010 | .027 | -4.1 |
| | 1.02 | .010 | .0102 | .009 | .027 | -4.1 |
| | 2.08 | .057 | .0114 | .007 | .026 | -4.1 |
| | 4.21 | .152 | .0169 | .001 | .023 | -4.1 |
| | 6.25 | .252 | .0284 | -.005 | .020 | -4.1 |
| | 8.35 | .350 | .0502 | -.009 | .025 | -4.1 |
| | 10.47 | .457 | .0807 | -.010 | .024 | -4.1 |
| | 12.56 | .545 | .1160 | -.008 | .025 | -4.1 |
| | 14.69 | .656 | .1637 | -.011 | .027 | -4.1 |
| | 16.81 | .762 | .2159 | -.012 | .027 | -4.1 |
| | 17.86 | .812 | .2489 | -.011 | .027 | -4.1 |
| 0.80 | -4.21 | -.229 | .0230 | .026 | .040 | -4.0 |
| | -2.10 | -.128 | .0140 | .018 | .037 | -4.0 |
| | -1.04 | -.079 | .0115 | .015 | .035 | -4.0 |
| | -.51 | -.055 | .0107 | .013 | .034 | -4.0 |
| | .50 | -.009 | .0101 | .009 | .032 | -4.0 |
| | 1.03 | .016 | .0104 | .008 | .031 | -4.0 |
| | 2.04 | .064 | .0118 | .005 | .029 | -4.0 |
| | 4.16 | .165 | .0186 | -.002 | .024 | -4.1 |
| | 6.28 | .270 | .0325 | -.010 | .023 | -4.1 |
| | 8.39 | .369 | .0552 | -.011 | .020 | -4.1 |
| | 10.51 | .468 | .0870 | -.012 | .020 | -4.1 |
| | 12.63 | .574 | .1283 | -.022 | .019 | -4.1 |
| | 14.77 | .683 | .1787 | -.027 | .020 | -4.1 |
| | 16.89 | .793 | .2389 | -.035 | .022 | -4.1 |
| | 17.96 | .852 | .2736 | -.040 | .016 | -4.1 |
| 0.90 | -4.23 | -.247 | .0268 | .032 | .031 | -4.0 |
| | -2.11 | -.138 | .0161 | .021 | .026 | -4.0 |
| | -1.05 | -.085 | .0130 | .017 | .025 | -4.0 |
| | -.51 | -.058 | .0119 | .015 | .024 | -4.1 |
| | .50 | -.010 | .0113 | .010 | .024 | -4.1 |
| | 1.14 | .018 | .0117 | .008 | .023 | -4.1 |
| | 2.06 | .070 | .0148 | .004 | .022 | -4.1 |

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 0.90 | 4.18 | 0.179 | 0.0212 | -0.006 | 0.023 | -4.1 |
| | 6.31 | .285 | .0372 | -.010 | .024 | -4.1 |
| | 8.43 | .388 | .0619 | -.015 | .028 | -4.0 |
| | 10.58 | .533 | .1029 | - - - | .026 | -4.0 |
| 1.20 | -4.08 | -.229 | .0302 | .046 | .030 | -4.0 |
| | -2.03 | -.124 | .0197 | .027 | .028 | -4.0 |
| | -1.00 | -.072 | .0169 | .018 | .028 | -4.0 |
| | -.47 | -.046 | .0160 | .014 | .027 | -4.0 |
| | .51 | .003 | .0156 | .006 | .027 | -4.0 |
| | 1.05 | .029 | .0161 | .001 | .026 | -4.0 |
| | 2.04 | .078 | .0182 | -.007 | .026 | -4.0 |
| | 4.10 | .182 | .0269 | -.026 | .025 | -4.0 |
| | 6.15 | .288 | .0426 | -.043 | .026 | -4.0 |
| | 8.21 | .393 | .0664 | -.061 | .031 | -4.0 |
| | 10.30 | .490 | .0986 | -.076 | .032 | -4.0 |
| | 12.37 | .615 | .1397 | -.096 | .035 | -4.0 |
| 1.30 | -4.08 | -.209 | .0312 | .040 | .028 | -4.0 |
| | -2.03 | -.113 | .0216 | .024 | .027 | -4.0 |
| | -1.00 | -.065 | .0188 | .016 | .027 | -4.0 |
| | -.47 | -.042 | .0180 | .012 | .027 | -4.0 |
| | .51 | .004 | .0176 | .005 | .028 | -4.0 |
| | 1.05 | .027 | .0182 | .002 | .029 | -4.0 |
| | 2.04 | .074 | .0204 | -.006 | .028 | -4.0 |
| | 4.09 | .169 | .0285 | -.022 | .028 | -4.0 |
| | 6.15 | .266 | .0432 | -.038 | .030 | -4.0 |
| | 8.20 | .359 | .0647 | -.052 | .034 | -4.0 |
| | 10.28 | .452 | .0935 | -.066 | .033 | -4.0 |
| | 12.34 | .544 | .1289 | -.080 | .031 | -4.0 |
| | 14.40 | .632 | .1708 | -.093 | .027 | -4.0 |
| 1.50 | -4.08 | -.189 | .0268 | .036 | .031 | -4.0 |
| | -2.02 | -.102 | .0198 | .022 | .030 | -4.0 |
| | -.99 | -.057 | .0171 | .014 | .029 | -4.0 |
| | -.47 | -.036 | .0158 | .011 | .029 | -4.0 |
| | .52 | .006 | .0153 | .004 | .029 | -4.0 |
| | .83 | .027 | .0161 | .001 | .028 | -4.0 |

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 1.50 | 2.04 | 0.069 | 0.0185 | -0.006 | 0.028 | -4.0 |
| | 4.09 | .158 | .0262 | -.020 | .026 | -4.0 |
| | 6.15 | .244 | .0396 | -.034 | .026 | -4.0 |
| | 8.20 | .327 | .0590 | -.047 | .026 | -4.0 |
| | 10.27 | .410 | .0851 | -.059 | .025 | -4.0 |
| | 12.33 | .489 | .1161 | -.070 | .024 | -4.0 |
| | 14.39 | .567 | .1531 | -.081 | .020 | -4.0 |
| 1.70 | -4.07 | -.171 | .0268 | .031 | .027 | -4.0 |
| | -2.02 | -.092 | .0184 | .019 | .026 | -4.0 |
| | -1.00 | -.052 | .0161 | .012 | .025 | -4.0 |
| | -.47 | -.032 | .0155 | .009 | .025 | -4.0 |
| | .51 | .006 | .0152 | .003 | .025 | -4.0 |
| | 1.05 | .025 | .0156 | 0 | .025 | -4.0 |
| | 2.03 | .065 | .0174 | -.006 | .024 | -4.0 |
| | 4.08 | .143 | .0246 | -.018 | .023 | -4.0 |
| | 6.13 | .220 | .0369 | -.030 | .023 | -4.0 |
| | 8.18 | .298 | .0548 | -.041 | .022 | -4.0 |
| | 10.23 | .368 | .0771 | -.051 | .021 | -4.0 |
| | 12.30 | .439 | .1051 | -.061 | .020 | -4.0 |
| | 14.35 | .507 | .1381 | -.069 | .018 | -4.1 |
| | 16.41 | .573 | .1756 | -.076 | .013 | -4.1 |
| | 17.43 | .608 | .1970 | -.079 | .009 | -4.1 |
| 1.90 | -4.06 | -.154 | .0259 | .026 | .021 | -4.0 |
| | -2.02 | -.083 | .0184 | .015 | .020 | -4.0 |
| | -.99 | -.047 | .0164 | .010 | .020 | -4.0 |
| | -.47 | -.029 | .0159 | .007 | .020 | -4.0 |
| | .51 | .005 | .0157 | .003 | .019 | -4.0 |
| | 1.05 | .022 | .0160 | 0 | .019 | -4.1 |
| | 2.03 | .058 | .0175 | -.005 | .019 | -4.1 |
| | 4.07 | .128 | .0240 | -.015 | .018 | -4.1 |
| | 6.12 | .196 | .0349 | -.025 | .018 | -4.1 |
| | 8.17 | .266 | .0508 | -.034 | .017 | -4.1 |
| | 10.21 | .331 | .0711 | -.043 | .016 | -4.1 |
| | 12.26 | .393 | .0957 | -.050 | .015 | -4.1 |
| | 14.32 | .455 | .1254 | -.057 | .013 | -4.1 |
| | 16.38 | .516 | .1597 | -.061 | .009 | -4.1 |
| | 17.41 | .549 | .1793 | -.063 | .009 | -4.1 |

(d) Nominal $\delta = -8^\circ$

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 0.60 | -4.18 | -0.227 | 0.0185 | 0.027 | 0.045 | -8.0 |
| | -2.09 | -.133 | .0155 | .021 | .044 | -8.0 |
| | -1.04 | -.088 | .0128 | .018 | .044 | -8.0 |
| | -.51 | -.063 | .0121 | .017 | .044 | -8.0 |
| | .49 | -.021 | .0114 | .015 | .042 | -8.1 |
| | 1.02 | .003 | .0117 | .014 | .042 | -8.1 |
| | 2.08 | .049 | .0130 | .012 | .042 | -8.1 |
| | 4.13 | .142 | .0178 | .006 | .041 | -8.1 |
| | 6.22 | .241 | .0292 | .001 | .042 | -8.1 |
| | 8.33 | .342 | .0503 | -.003 | .045 | -8.0 |
| | 10.43 | .436 | .0795 | 0 | .045 | -8.0 |
| | 12.54 | .540 | .1174 | -.001 | .045 | -8.0 |
| | 14.65 | .646 | .1635 | -.004 | .047 | -8.0 |
| | 16.79 | .739 | .2242 | -.005 | .049 | -8.0 |
| | 17.83 | .794 | .2490 | -.005 | .045 | -8.0 |
| 0.80 | -4.21 | -.240 | .0162 | .031 | .054 | -8.0 |
| | -2.10 | -.140 | .0164 | .024 | .052 | -8.0 |
| | -1.05 | -.091 | .0135 | .021 | .052 | -8.0 |
| | -.51 | -.066 | .0127 | .019 | .051 | -8.0 |
| | .49 | -.023 | .0118 | .016 | .051 | -8.0 |
| | 1.02 | - - - | .0120 | .015 | .051 | -8.0 |
| | 2.09 | .051 | - - - | .012 | .051 | -8.0 |
| | 4.15 | .150 | - - - | .061 | .051 | -8.0 |
| | 6.27 | .255 | .0328 | -.002 | .051 | -8.0 |
| | 8.39 | .354 | .0547 | -.002 | .052 | -8.0 |
| | 10.50 | .448 | .0844 | -.002 | .055 | -7.9 |
| | 12.62 | .563 | .1260 | .014 | .051 | -7.9 |
| | 14.75 | .675 | .1770 | .021 | .051 | -8.0 |
| | 16.88 | .786 | .2372 | -.028 | .049 | -8.0 |
| | 17.94 | .843 | .2708 | -.034 | .041 | -8.0 |
| 0.90 | -4.24 | -.263 | .0308 | .040 | .058 | -7.9 |
| | -1.99 | - - - | .0160 | - - - | .059 | -7.9 |
| | -1.06 | - - - | .0161 | .026 | .061 | -7.9 |
| | -.53 | -.075 | .0150 | .023 | .062 | -7.9 |
| | .48 | -.028 | .0139 | .020 | .061 | -7.9 |
| | 1.02 | -.002 | .0142 | .018 | .061 | -7.9 |
| | 2.10 | .052 | - - - | .014 | .058 | -7.9 |

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 0.90 | 4.17 | 0.160 | 0.0232 | 0.004 | 0.057 | -7.9 |
| | 6.30 | .268 | .0384 | -.003 | .058 | -7.9 |
| | 8.42 | .375 | .0628 | -.008 | .061 | -7.9 |
| | 10.57 | .485 | .0970 | -.016 | .058 | -7.9 |
| 1.20 | -4.09 | -.242 | .0330 | .053 | .082 | -7.6 |
| | -2.03 | -.135 | .0221 | .034 | .080 | -7.6 |
| | -.10 | -.083 | .0190 | .025 | .082 | -7.6 |
| | -.48 | -.058 | .0181 | .021 | .081 | -7.6 |
| | .51 | .009 | .0175 | .013 | .079 | -7.6 |
| | 1.04 | .018 | .0179 | .008 | .078 | -7.6 |
| | 2.03 | .068 | .0212 | 0 | .077 | -7.6 |
| | 4.08 | .172 | .0281 | -.018 | .076 | -7.6 |
| | 6.15 | .279 | .0438 | -.036 | .077 | -7.6 |
| | 8.21 | .383 | .0673 | -.054 | .084 | -7.6 |
| | 10.27 | .489 | .0988 | -.069 | .084 | -7.6 |
| | 12.34 | .607 | .1395 | -.090 | .081 | -7.6 |
| 1.30 | -4.08 | -.221 | .0343 | .047 | .083 | -7.6 |
| | -2.02 | -.123 | .0241 | .033 | .079 | -7.6 |
| | -1.00 | -.075 | .0211 | .022 | .081 | -7.6 |
| | -.51 | -.052 | .0202 | .019 | .079 | -7.6 |
| | -.51 | -.006 | .0195 | .012 | .076 | -7.6 |
| | 1.04 | .018 | .0201 | .008 | .076 | -7.6 |
| | 2.03 | .066 | .0221 | 0 | .075 | -7.6 |
| | 4.08 | .160 | .0299 | -.016 | .072 | -7.7 |
| | 6.14 | .257 | .0442 | -.035 | .074 | -7.6 |
| | 8.20 | .351 | .0656 | -.047 | .076 | -7.6 |
| | 10.26 | .447 | .0941 | -.062 | .073 | -7.7 |
| | 12.32 | .537 | .1291 | -.075 | .073 | -7.6 |
| | 14.38 | .625 | .1704 | -.088 | .068 | -7.7 |
| 1.50 | -4.07 | -.202 | .0311 | .043 | .078 | -7.6 |
| | -2.02 | -.111 | .0250 | .028 | .076 | -7.6 |
| | -.99 | -.068 | .0186 | .021 | .075 | -7.6 |
| | -.47 | -.047 | .0174 | .018 | .075 | -7.6 |
| | .51 | -.007 | .0170 | .011 | .074 | -7.6 |
| | 1.04 | .017 | .0177 | .008 | .074 | -7.6 |
| | 2.02 | .060 | .0198 | .001 | .073 | -7.6 |

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 1.50 | 4.08 | 0.147 | 0.0272 | -0.014 | 0.072 | -7.6 |
| | 6.13 | .235 | .0404 | -.028 | .073 | -7.6 |
| | 8.19 | .321 | .0596 | -.041 | .078 | -7.6 |
| | 10.24 | .401 | .0849 | -.054 | .083 | -7.7 |
| | 12.29 | .483 | .1159 | -.067 | .068 | -7.6 |
| | 14.35 | .562 | .1528 | -.078 | .064 | -7.7 |
| | 16.40 | .636 | .1949 | -.088 | .059 | -7.7 |
| 1.70 | -4.07 | -.180 | .0290 | .037 | .064 | -7.7 |
| | -2.02 | -.101 | .0203 | .024 | .063 | -7.7 |
| | -.99 | -.061 | .0177 | .018 | .062 | -7.7 |
| | -.47 | -.042 | .0168 | .015 | .061 | -7.7 |
| | .51 | -.004 | .0164 | .009 | .061 | -7.7 |
| | 1.03 | .018 | .0168 | .005 | .061 | -7.7 |
| | 2.02 | .057 | .0196 | -.001 | .060 | -7.7 |
| | 4.07 | .134 | .0255 | -.013 | .060 | -7.7 |
| | 6.12 | .211 | .0375 | -.025 | .060 | -7.7 |
| | 8.17 | .288 | .0548 | -.036 | .058 | -7.7 |
| | 10.21 | .358 | .0769 | -.046 | .058 | -7.7 |
| | 12.26 | .429 | .1042 | -.056 | .057 | -7.8 |
| | 14.31 | .498 | .1364 | -.065 | .048 | -7.8 |
| | 16.37 | .565 | .1742 | -.072 | .050 | -7.8 |
| | 17.40 | .600 | .1949 | -.075 | .046 | -7.8 |
| 1.90 | -4.06 | -.161 | .0276 | .030 | .056 | -7.8 |
| | -2.01 | -.090 | .0198 | .020 | .055 | -7.8 |
| | -.99 | -.054 | .0178 | .014 | .055 | -7.8 |
| | -.47 | -.036 | .0171 | .012 | .055 | -7.8 |
| | .51 | -.003 | .0168 | .007 | .054 | -7.8 |
| | 1.03 | .017 | .0170 | .004 | .054 | -7.8 |
| | 2.01 | .051 | .0193 | -.001 | .054 | -7.8 |
| | 4.06 | .121 | .0245 | -.011 | .054 | -7.8 |
| | 6.10 | .190 | .0351 | -.021 | .053 | -7.8 |
| | 8.14 | .259 | .0505 | -.031 | .052 | -7.8 |
| | 10.19 | .325 | .0708 | -.039 | .051 | -7.8 |
| | 12.23 | .385 | .0943 | -.046 | .050 | -7.8 |
| | 14.28 | .446 | .1231 | -.052 | .048 | -7.8 |
| | 16.33 | .506 | .1566 | -.057 | .048 | -7.9 |
| | 17.36 | .538 | .1760 | -.059 | .041 | -7.9 |

TABLE I.- AERODYNAMIC CHARACTERISTICS OF A TRIANGULAR WING EQUIPPED WITH A PADDLE CONTROL. DATA FOR ONE PADDLE CONTROL. $R = 3.0\times10^{6}$ - Concluded

(e) Nominal $\delta = -12^{\circ}$

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 0.60 | -4.18 | -0.228 | 0.0270 | 0.027 | 0.060 | -12.0 |
| | -2.09 | -.136 | .0191 | .021 | .058 | -12.0 |
| | -1.04 | -.089 | .0165 | .018 | .057 | -12.0 |
| | -.51 | -.066 | .0156 | .017 | .057 | -12.0 |
| | .48 | -.026 | .0148 | .016 | .057 | -12.0 |
| | 1.01 | -.009 | .0149 | .015 | .056 | -12.0 |
| | 2.07 | .044 | .0160 | .013 | .056 | -12.1 |
| | 4.12 | .133 | .0204 | .099 | .054 | -12.1 |
| | 6.22 | .231 | .0309 | .004 | .054 | -12.1 |
| | 8.32 | .330 | .0500 | .002 | .054 | -12.1 |
| | 10.43 | .424 | .0773 | .005 | .054 | -12.1 |
| | 12.54 | .526 | .1159 | .004 | .054 | -12.1 |
| | 14.65 | .630 | .1609 | .001 | .057 | -12.0 |
| | 16.76 | .732 | .2133 | 0 | .058 | -12.0 |
| | 17.82 | .789 | .2446 | 0 | .057 | -12.0 |
| 0.80 | -4.22 | -.242 | .0293 | .033 | .062 | -12.0 |
| | -2.11 | -.143 | .0196 | .025 | .060 | -12.0 |
| | -1.05 | -.093 | .0168 | .022 | .059 | -12.0 |
| | -.52 | -.068 | .0158 | .020 | .058 | -12.0 |
| | .48 | -.025 | .0150 | .018 | .058 | -12.0 |
| | 1.02 | -.002 | .0151 | .016 | .057 | -12.0 |
| | 2.09 | -.048 | .0165 | .014 | .057 | -12.0 |
| | 4.15 | .144 | .0220 | .008 | .056 | -12.0 |
| | 6.27 | .248 | .0351 | .001 | .057 | -12.0 |
| | 8.38 | .342 | .0561 | .003 | .062 | -12.0 |
| | 10.50 | .438 | .0857 | .004 | .067 | -11.9 |
| | 12.62 | .549 | .1257 | -.008 | .065 | -11.9 |
| | 14.75 | .661 | .1756 | -.015 | .069 | -11.9 |
| | 16.87 | .766 | .2327 | -.021 | .071 | -11.9 |
| | 17.93 | .820 | .2650 | -.026 | .068 | -11.9 |
| 0.90 | -4.24 | -.263 | .0338 | .040 | .082 | -11.8 |
| | -2.06 | -.108 | .0205 | .033 | .078 | -11.8 |
| | -1.06 | -.098 | .0190 | .025 | .080 | -11.8 |
| | .49 | -.026 | .0168 | .020 | .077 | -11.8 |
| | 1.03 | .001 | .0170 | .018 | .076 | -11.8 |
| | 2.10 | .053 | .0188 | .014 | .078 | -11.8 |
| 0.90 | 4.17 | 0.158 | 0.0256 | 0.006 | 0.074 | -11.8 |
| | 6.30 | .265 | .0411 | -.001 | .084 | -11.8 |
| | 8.43 | .368 | .0654 | -.003 | .091 | -11.7 |
| | 10.55 | .473 | .0985 | -.010 | .092 | -11.7 |
| 1.20 | -4.08 | -.250 | .0369 | .059 | .100 | -11.6 |
| | -2.22 | -.142 | .0258 | .040 | .101 | -11.6 |
| | -.10 | -.091 | .0227 | .031 | .103 | -11.5 |
| | -.48 | -.066 | .0217 | .027 | .102 | -11.5 |
| | .51 | -.019 | .0209 | .019 | .101 | -11.6 |
| | 1.04 | .010 | .0212 | .014 | .100 | -11.6 |
| | 2.03 | .060 | .0230 | .006 | .099 | -11.6 |
| | 4.09 | .162 | .0308 | -.012 | .099 | -11.6 |
| | 6.15 | .268 | .0459 | -.030 | .101 | -11.6 |
| | 8.21 | .372 | .0695 | -.047 | .104 | -11.5 |
| | 10.28 | .479 | .1001 | -.063 | .104 | -11.5 |
| | 12.35 | .598 | .1408 | -.084 | .100 | -11.6 |
| 1.30 | -4.08 | -.230 | .0384 | .053 | .094 | -11.6 |
| | -2.21 | -.130 | .0279 | .036 | .094 | -11.6 |
| | -.99 | -.088 | .0249 | .028 | .096 | -11.6 |
| | -.48 | -.058 | .0238 | .024 | .095 | -11.6 |
| | .51 | -.014 | .0230 | .016 | .093 | -11.6 |
| | 1.04 | .011 | .0234 | .012 | .092 | -11.6 |
| | 2.03 | .059 | .0253 | .004 | .091 | -11.6 |
| | 4.08 | .154 | .0328 | -.012 | .087 | -11.6 |
| | 6.14 | .250 | .0468 | -.028 | .086 | -11.6 |
| | 8.20 | .343 | .0678 | -.042 | .087 | -11.6 |
| | 10.26 | .438 | .0956 | -.057 | .085 | -11.7 |
| | 12.32 | .529 | .1300 | -.071 | .083 | -11.7 |
| | 14.38 | .618 | .1712 | -.084 | .078 | -11.7 |
| 1.50 | -4.07 | -.208 | .0348 | .049 | .086 | -11.6 |
| | -2.02 | -.120 | .0252 | .034 | .087 | -11.6 |
| | -.99 | -.077 | .0220 | .027 | .087 | -11.6 |
| | -.47 | -.055 | .0208 | .024 | .086 | -11.6 |
| | .51 | -.015 | .0203 | .017 | .092 | -11.6 |
| | 1.04 | .008 | .0210 | .013 | .092 | -11.6 |
| 1.50 | 2.08 | 0.054 | 0.0235 | 0.005 | 0.091 | -11.6 |
| | 4.08 | .139 | .0306 | -.009 | .087 | -11.6 |
| | 6.13 | .226 | .0434 | -.023 | .084 | -11.6 |
| | 8.19 | .312 | .0625 | -.036 | .084 | -11.6 |
| | 10.24 | .394 | .0869 | -.050 | .079 | -11.7 |
| | 12.29 | .475 | .1169 | -.063 | .072 | -11.7 |
| | 14.35 | .553 | .1532 | -.075 | .067 | -11.8 |
| | 16.41 | .626 | .1950 | -.085 | .062 | -11.8 |
| 1.70 | -4.06 | -.186 | .0321 | .042 | .093 | -11.5 |
| | -2.01 | -.106 | .0232 | .030 | .092 | -11.6 |
| | -.99 | -.067 | .0205 | .023 | .091 | -11.6 |
| | -.47 | -.047 | .0197 | .020 | .090 | -11.6 |
| | .51 | -.011 | .0192 | .014 | .090 | -11.6 |
| | 1.04 | .011 | .0195 | .011 | .089 | -11.6 |
| | 2.08 | .050 | .0212 | .005 | .089 | -11.6 |
| | 4.75 | .127 | .0278 | -.007 | .089 | -11.6 |
| | 6.13 | .204 | .0394 | -.019 | .088 | -11.6 |
| | 8.18 | .281 | .0564 | -.030 | .086 | -11.6 |
| | 10.23 | .352 | .0784 | -.041 | .087 | -11.6 |
| | 12.28 | .425 | .1059 | -.052 | .084 | -11.6 |
| | 14.33 | .495 | .1361 | -.061 | .077 | -11.7 |
| | 16.39 | .563 | .1759 | -.069 | .071 | -11.7 |
| | 17.41 | .599 | .1973 | -.073 | .069 | -11.7 |
| 1.90 | -4.05 | -.166 | .0347 | .035 | .085 | -11.7 |
| | -2.01 | -.094 | .0226 | .024 | .084 | -11.7 |
| | -.99 | -.059 | .0204 | .019 | .083 | -11.7 |
| | -.47 | -.041 | .0198 | .016 | .083 | -11.7 |
| | .51 | -.009 | .0193 | .011 | .083 | -11.7 |
| | 1.03 | .008 | .0194 | .009 | .082 | -11.7 |
| | 2.01 | .046 | .0207 | .004 | .082 | -11.7 |
| | 4.06 | .115 | .0268 | -.007 | .082 | -11.7 |
| | 6.10 | .184 | .0374 | -.016 | .082 | -11.7 |
| | 8.15 | .253 | .0528 | -.026 | .080 | -11.7 |
| | 10.19 | .320 | .0728 | -.034 | .079 | -11.7 |
| | 12.24 | .380 | .0962 | -.041 | .077 | -11.7 |
| | 14.28 | .440 | .1243 | -.047 | .068 | -11.8 |
| | 16.33 | .502 | .1579 | -.053 | .064 | -11.8 |
| | 17.36 | .534 | .1774 | -.058 | .065 | -11.8 |

(f) Nominal $\delta = -16^{\circ}$

| M | α | $C_L$ | $C_D$ | $C_m$ | $C_h$ | δ |
|---|---|---|---|---|---|---|
| 0.60 | -4.18 | -0.224 | 0.0310 | 0.025 | 0.067 | -16.0 |
| | -2.09 | -.130 | .0230 | .020 | .066 | -16.0 |
| | -1.04 | -.087 | .0205 | .018 | .066 | -16.0 |
| | -.51 | -.064 | .0198 | .017 | .066 | -16.0 |
| | .49 | -.022 | .0188 | .015 | .065 | -16.0 |
| | 1.02 | .003 | .0189 | .014 | .064 | -16.0 |
| | 2.08 | .049 | .0201 | .012 | .063 | -16.0 |
| | 4.12 | .136 | .0245 | .009 | .063 | -16.0 |
| | 6.22 | .232 | .0348 | .004 | .066 | -16.0 |
| | 8.32 | .329 | .0539 | .002 | .069 | -16.0 |
| | 10.42 | .420 | .0800 | .006 | .072 | -16.0 |
| | 12.54 | .528 | .1175 | .005 | .073 | -16.0 |
| | 14.64 | .627 | .1630 | .003 | .076 | -16.0 |
| | 16.76 | .732 | .2179 | .003 | .077 | -16.0 |
| | 17.82 | .782 | .2470 | .003 | .076 | -16.0 |
| 0.80 | -4.21 | -.236 | .0333 | .029 | .072 | -15.9 |
| | -2.10 | -.135 | .0240 | .021 | .071 | -15.9 |
| | -1.05 | -.087 | .0211 | .018 | .071 | -15.9 |
| | -.51 | -.063 | .0202 | .017 | .071 | -15.9 |
| | .49 | -.020 | .0194 | .014 | .070 | -15.9 |
| | 1.02 | .005 | .0196 | .013 | .070 | -15.9 |
| | 2.10 | .054 | .0209 | .010 | .069 | -15.9 |
| | 4.16 | .150 | .0267 | .004 | .067 | -15.9 |
| | 6.27 | .253 | .0401 | -.003 | .069 | -15.9 |
| | 8.38 | .343 | .0605 | .001 | .071 | -15.9 |
| | 10.50 | .431 | .0885 | .006 | .081 | -15.8 |
| | 12.62 | .548 | .1297 | -.007 | .078 | -15.9 |
| | 14.75 | .657 | .1781 | -.013 | .084 | -15.8 |
| | 16.87 | .762 | .2355 | -.018 | .091 | -15.8 |
| 0.90 | -4.24 | -.267 | .0394 | .043 | .106 | -15.7 |
| | -2.12 | -.157 | .0279 | .032 | .103 | -15.7 |
| | -1.06 | -.104 | .0243 | .027 | .103 | -15.7 |
| | -.53 | -.079 | .0232 | .025 | .102 | -15.7 |
| | .48 | -.032 | .0221 | .022 | .101 | -15.7 |
| | 1.02 | -.007 | .0222 | .020 | .100 | -15.7 |
| | 2.10 | .047 | .0236 | .017 | .100 | -15.7 |
| | 4.17 | .153 | .0274 | .008 | .101 | -15.7 |
| 0.90 | 6.30 | 0.259 | 0.0460 | 0.002 | 0.115 | -15.7 |
| | 8.42 | .359 | .0694 | .001 | .120 | -15.6 |
| | 10.54 | .466 | .1022 | -.007 | .121 | -15.6 |
| 1.20 | -4.08 | -.255 | .0420 | .064 | .117 | -15.4 |
| | -2.02 | -.149 | .0309 | .044 | .117 | -15.4 |
| | -.99 | -.096 | .0276 | .035 | .119 | -15.4 |
| | -.48 | -.070 | .0266 | .031 | .119 | -15.4 |
| | .51 | -.024 | .0256 | .023 | .118 | -15.4 |
| | 1.04 | .004 | .0260 | .018 | .117 | -15.4 |
| | 2.09 | .056 | .0276 | .010 | .117 | -15.4 |
| | 4.09 | .156 | .0351 | -.008 | .118 | -15.4 |
| | 6.15 | .262 | .0500 | -.026 | .119 | -15.4 |
| | 8.21 | .367 | .0730 | -.043 | .122 | -15.4 |
| | 10.28 | .474 | .1032 | -.058 | .119 | -15.4 |
| | 12.35 | .595 | .1438 | -.080 | .114 | -15.5 |
| 1.30 | -4.07 | -.235 | .0428 | .059 | .106 | -15.5 |
| | -2.02 | -.138 | .0323 | .048 | .108 | -15.5 |
| | -.99 | -.090 | .0292 | .033 | .112 | -15.5 |
| | -.48 | -.068 | .0281 | .030 | .112 | -15.5 |
| | -.51 | -.022 | .0272 | .022 | .110 | -15.5 |
| | 1.04 | .004 | .0274 | .018 | .109 | -15.5 |
| | 2.09 | .054 | .0291 | .009 | .108 | -15.5 |
| | 4.09 | .147 | .0363 | -.007 | .107 | -15.5 |
| | 6.14 | .244 | .0501 | -.024 | .107 | -15.5 |
| | 8.20 | .338 | .0709 | -.039 | .107 | -15.5 |
| | 10.26 | .435 | .0986 | -.054 | .106 | -15.5 |
| | 12.32 | .525 | .1325 | -.068 | .103 | -15.5 |
| | 14.38 | .617 | .1741 | -.082 | .098 | -15.6 |
| 1.50 | -4.07 | -.214 | .0400 | .053 | .097 | -15.5 |
| | -2.02 | -.125 | .0301 | .038 | .098 | -15.5 |
| | -.99 | -.081 | .0270 | .031 | .101 | -15.5 |
| | -.47 | -.062 | .0257 | .028 | .100 | -15.5 |
| | .51 | -.021 | .0248 | .021 | .099 | -15.5 |
| | 1.03 | .002 | .0254 | .017 | .100 | -15.5 |
| | 2.08 | .047 | .0293 | .097 | .101 | -15.5 |
| 1.50 | 4.08 | 0.133 | 0.0341 | -0.009 | 0.099 | -15.5 |
| | 6.14 | .219 | .0465 | -.019 | .098 | -15.5 |
| | 8.19 | .306 | .0652 | -.032 | .098 | -15.5 |
| | 10.24 | .389 | .0892 | -.047 | .092 | -15.6 |
| | 12.30 | .471 | .1192 | -.060 | .088 | -15.6 |
| | 14.35 | .551 | .1577 | -.072 | .085 | -15.6 |
| 1.70 | -4.06 | -.195 | .0363 | .048 | .090 | -15.6 |
| | -2.01 | -.117 | .0271 | .035 | .089 | -15.6 |
| | -.99 | -.077 | .0244 | .029 | .089 | -15.6 |
| | -.47 | -.058 | .0235 | .026 | .089 | -15.6 |
| | .51 | -.021 | .0227 | .020 | .088 | -15.6 |
| | 1.03 | .001 | .0229 | .017 | .088 | -15.6 |
| | 2.08 | .041 | .0244 | .010 | .088 | -15.6 |
| | 4.06 | .093 | .0291 | .002 | .087 | -15.6 |
| | 6.12 | .196 | .0432 | -.015 | .089 | -15.6 |
| | 8.17 | .274 | .0597 | -.027 | .086 | -15.6 |
| | 10.22 | .346 | .0804 | -.039 | .080 | -15.7 |
| | 12.27 | .418 | .1069 | -.049 | .075 | -15.7 |
| | 14.32 | .488 | .1389 | -.059 | .073 | -15.7 |
| | 16.38 | .558 | .1766 | -.067 | .069 | -15.8 |
| | 17.41 | .593 | .1978 | -.071 | .067 | -15.8 |
| 1.90 | -4.06 | -.175 | .0345 | .039 | .080 | -15.7 |
| | -2.01 | -.103 | .0262 | .029 | .080 | -15.7 |
| | -.99 | -.068 | .0238 | .024 | .079 | -15.7 |
| | -.47 | -.050 | .0231 | .021 | .079 | -15.7 |
| | .51 | -.017 | .0225 | .016 | .079 | -15.7 |
| | 1.03 | .002 | .0226 | .013 | .078 | -15.7 |
| | 2.07 | .039 | .0238 | .008 | .078 | -15.7 |
| | 4.06 | .108 | .0295 | -.002 | .078 | -15.7 |
| | 6.11 | .175 | .0396 | -.012 | .078 | -15.7 |
| | 8.15 | .244 | .0543 | -.021 | .076 | -15.7 |
| | - - - | - - - | - - - | - - - | - - - | - - - |
| | 12.25 | .371 | .0961 | -.037 | .065 | -15.8 |
| | 14.29 | .434 | .1259 | -.045 | .062 | -15.8 |
| | 16.35 | .497 | .1596 | -.050 | .058 | -15.8 |
| | 17.37 | .529 | .1790 | -.053 | .058 | -15.8 |

NACA

[redacted]

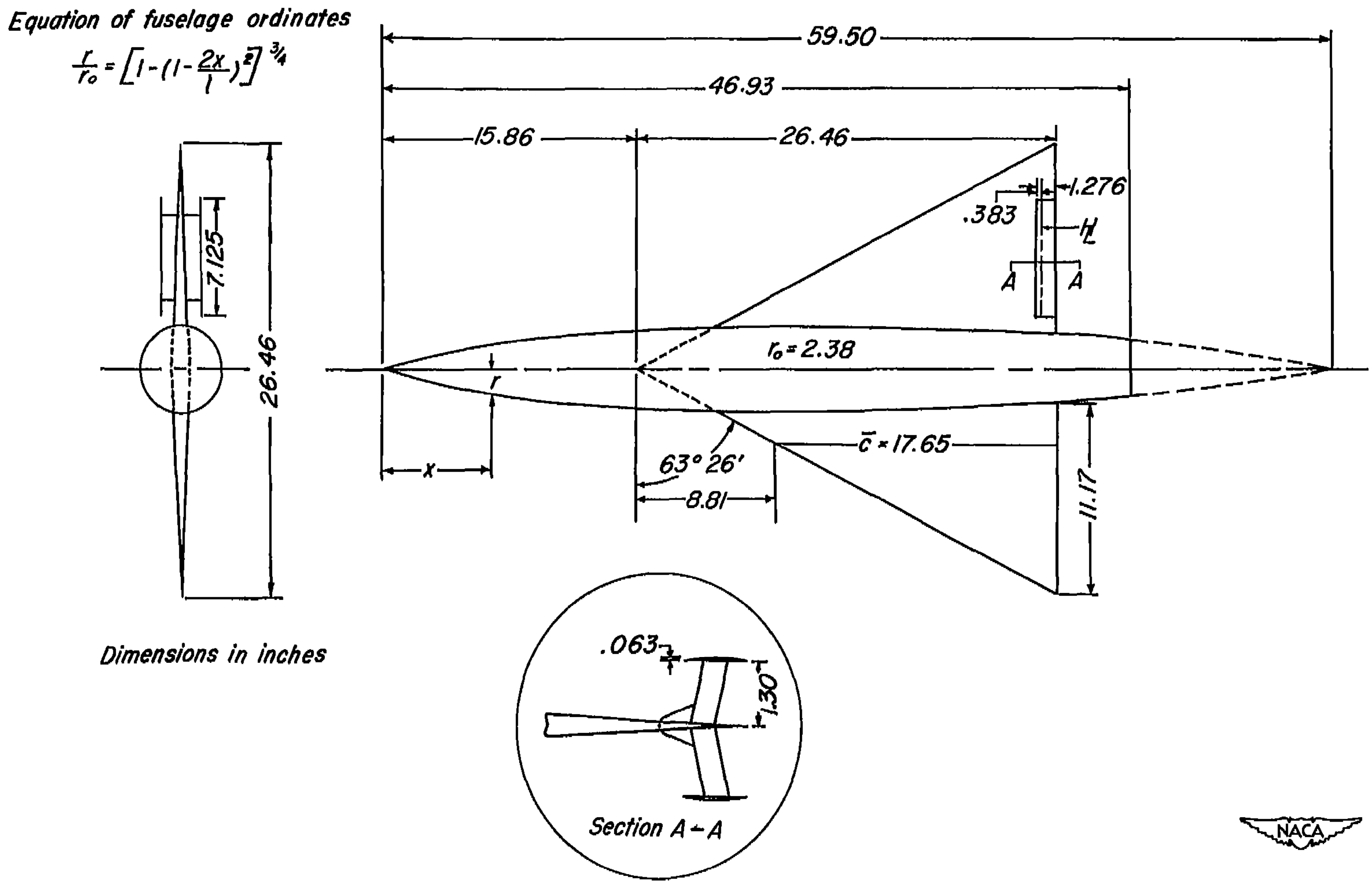
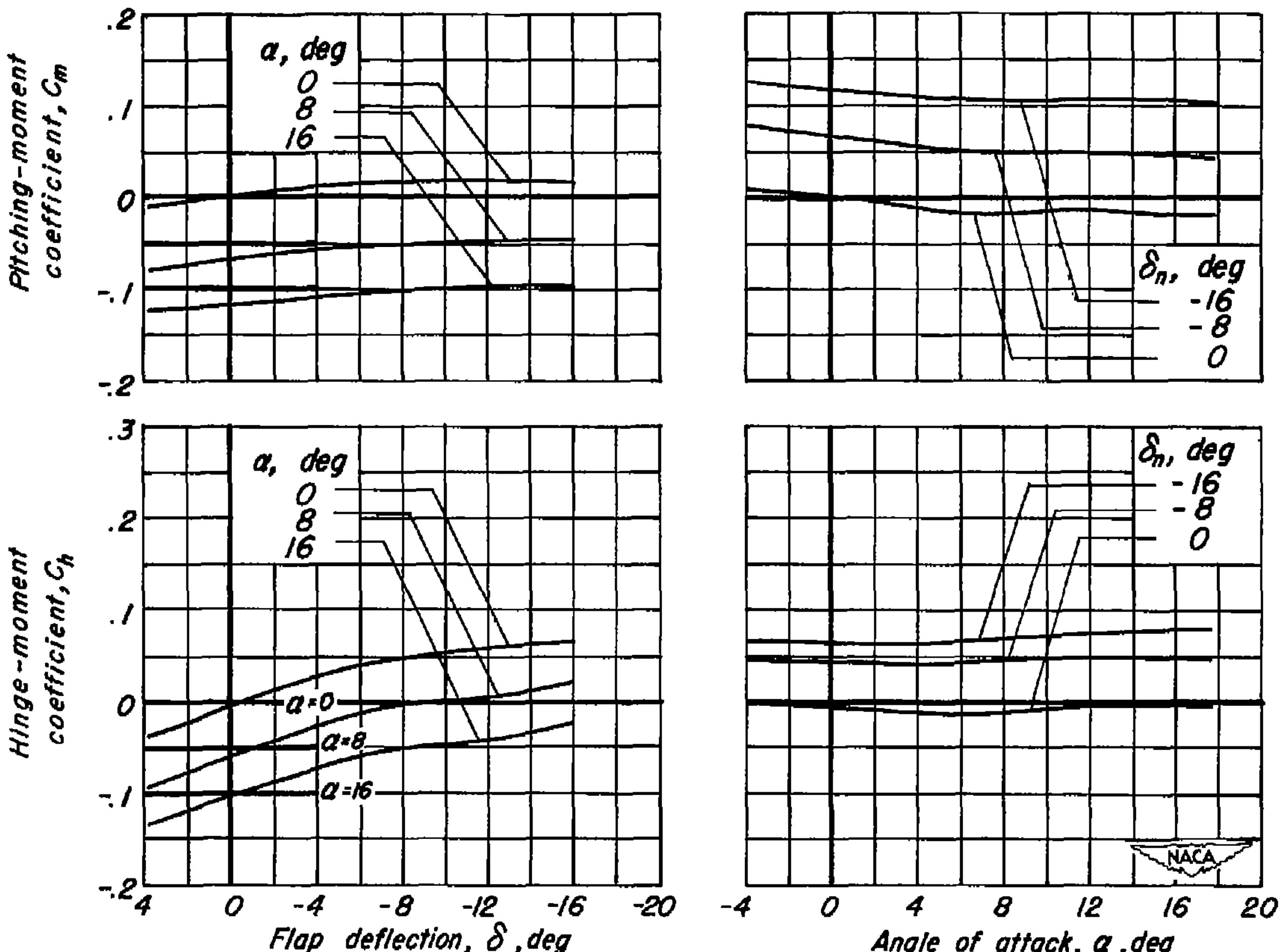


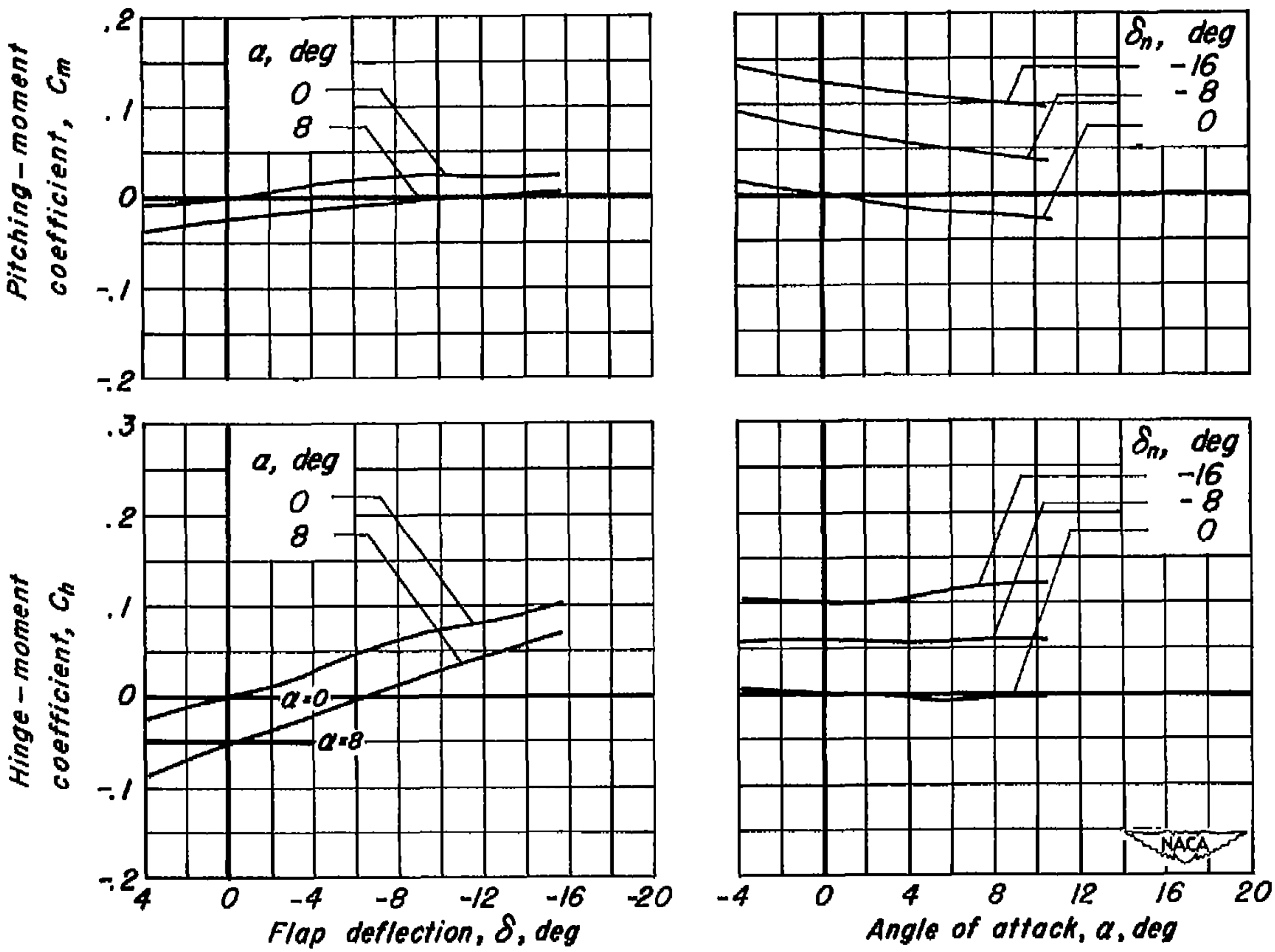

Figure 1.- Dimensional sketch of model.

[redacted]




(a) M = 0.60

*Figure 2.- The variation of the pitching-moment and the hinge-moment coefficients with paddle-control deflection and with angle of attack. Data for one paddle control. $R = 3.0 \times 10^6$.*




(b) M=0.90

Figure 2.- Continued.

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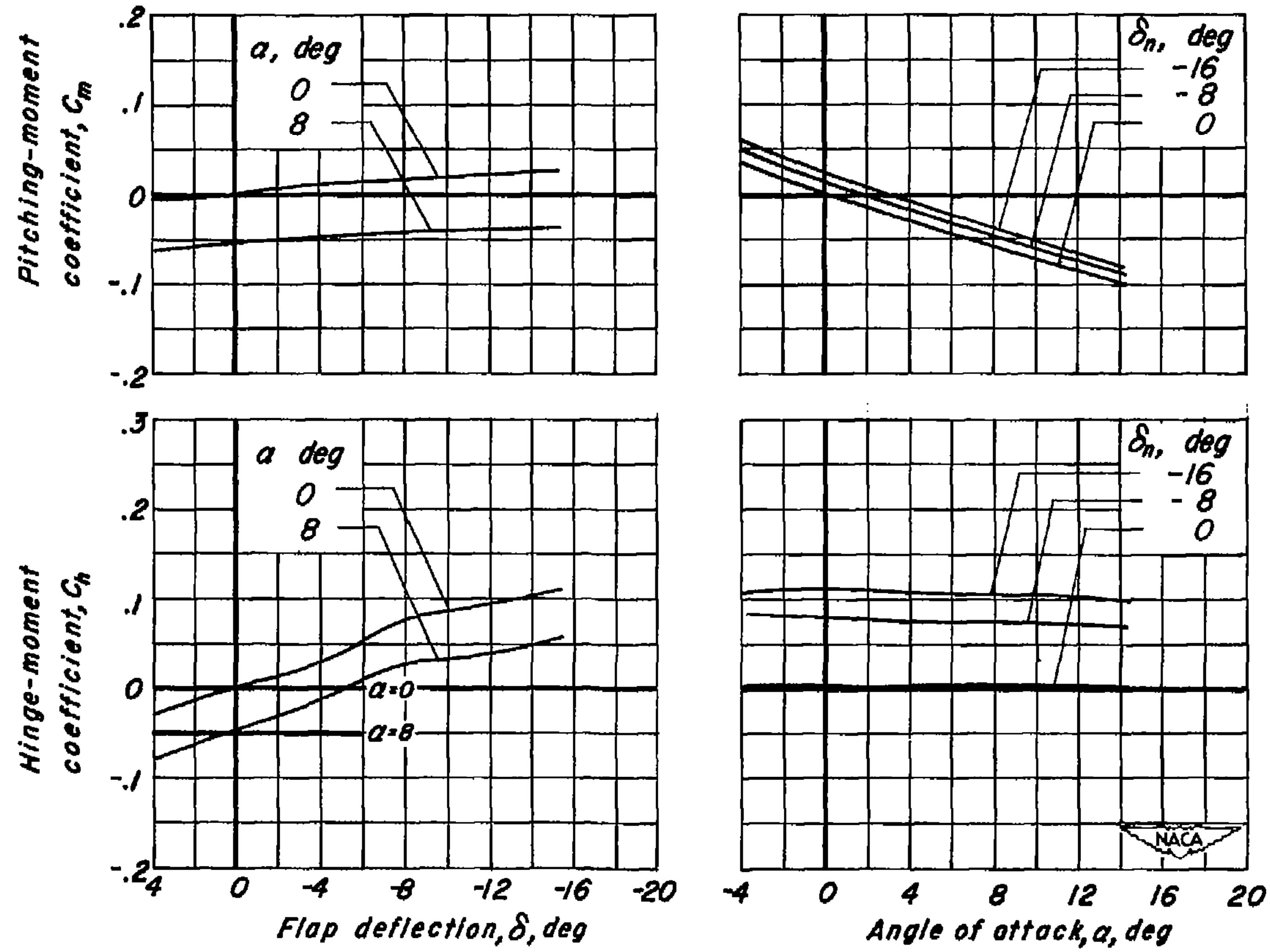


(c) M = 1.30

Figure 2.- Continued.

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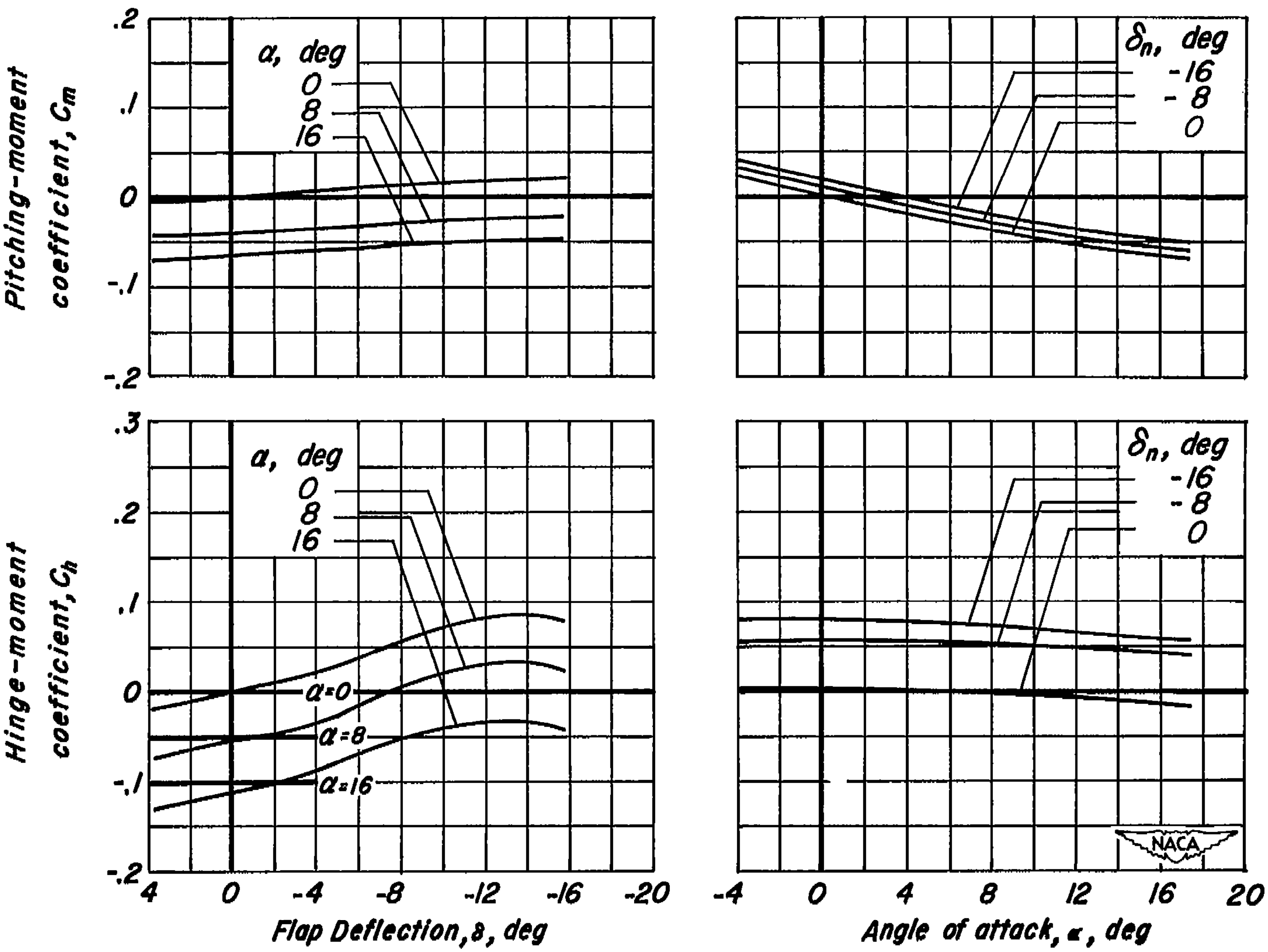


(d) M=1.90

Figure 2.- Concluded.

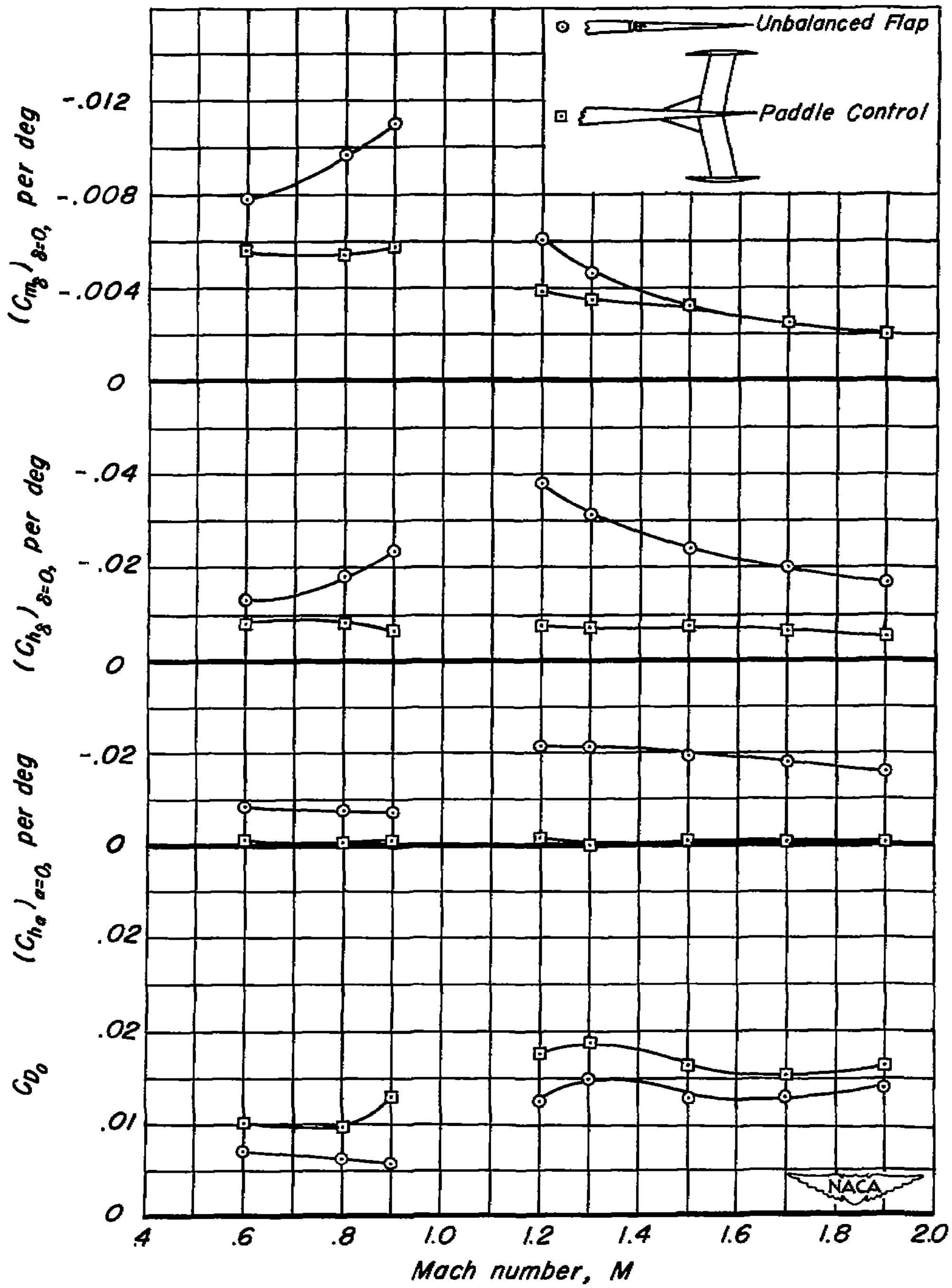


Figure 3.- Variation with Mach number of the pitching-moment-effectiveness parameter, $C_{m_\delta}$, the hinge-moment parameters, $C_{h_\delta}$, and $C_{h_\alpha}$, and the minimum drag coefficient, $C_{D_0}$, for the unbalanced flap and the paddle-control configurations. Data for two flaps.

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